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A SIMPLIFIED SERIAL SECTIONING TECHNIQUE FOR THE STUDY OF FOSSILS

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Thin sections are extensively used in the study of fossils. They are part of the standard technique for the study of some invertebrates (e.g., fusilinids) and plants (silicified wood, coal balls, etc.) and they are occasionally employed in vertebrate paleontology (e.g., the work by Carter on enamel histology and that by Moodie on pathologic tissues and ossified tendons). Serial thin sections, as employed so extensively in recent biology, would be of still greater value. If, however, such series were to be made with paleontological materials, the space lost between each section would be many times greater than the thickness of the sections themselves, and the successful preparation of many successive thin sections would be extremely arduous, require a high degree of skill and elaborate equipment, and involve at best some failures and many imperfect sections. Serial thin sections are very seldom practical in paleontological research.

To overcome these difficulties, W. J. Sollas[1] devised a technique for the preparation of serial opaque sections by grinding a specimen down to successive parallel planes. The specimen itself is destroyed, but its morphology is determined and permanently recorded by drawings or photographs and by models. This method adds immeasurably to the technical resources of paleontological research, and it has been employed with brilliant results by Sollas and by a few others, notably Stensiö.[2]

This technique is so promising and its results so remarkable that it is surprising to see how little use has been made of it. This relative neglect is apparently due mainly to two factors. In the first place, the most puzzling specimens and those most imperatively needing such a method for their elucidation are usually rare or even unique, so that any mode of study that destroys the original is unwarranted. This is an inherent

[1]Sollas, W. J. 1903. 'A method for the investigation of fossils by serial sections.' Phil. Trans. Roy. Soc. London, (B) CLXXXXVI, pp. 259–265.
Sollas, I. B. J., and W. J. Sollas. 1913. 'A study of the skull of *Dicynodon* by means of serial sections.' Phil. Trans. Roy. Soc. London, (B) CCIV, pp. 201–225.

[2]For example:
Stensiö, E. A. 1927. 'The Downtonian and Devonian vertebrates of Spitsbergen.' Part I. Family Cephalaspidae. Skrifter om Svalbard og Nordishavet, Norske Videns.-Akad. Oslo, No. 12.
1932. 'Triassic fishes from East Greenland.' Meddelelser om Grønland, Kom. Vidensk. Unders. Grønland, LXXXIII, No. 3.

disadvantage which sharply limits the use of serial sections, but it still leaves a large field of usefulness. Every collection does contain specimens that could be more usefully employed in this way than in any other. Furthermore, many symmetrical specimens, even though rare, could legitimately be divided into halves, one side to be used for sectioning and the other for surface morphology and permanent record. The second difficulty, which has probably been the more important reason for the neglect of this method, is that the preparation of adequate sections has usually demanded either remarkable skill and hard labor or else very expensive and complex apparatus.

The simple procedure here suggested seems in large measure to do away with the difficulty and expense of the serial sectioning of fossils. The results are valuable out of all proportion to the cost, in time or money, and it is hoped that a wide use of serial sections may result. The necessary apparatus need not cost more than a dollar or two and the procedure is very rapid and requires no special skill or training. The machines illustrated by Sollas probably give slightly more exact results, but in practice the present method proves to be entirely adequate for any reasonable purpose. More elaborate equipment or procedures could hardly produce a useful improvement in results.

This method involves no particular originality, and its publication is prompted only by the desire to share a useful tool with others. I am indebted to C. S. Williams for the actual construction of the apparatus and for some suggestions regarding its design and use. The method has been used in the study of parts of small mammal skulls. Serial sectioning does not appear to have been employed previously in the study of fossil mammals, but the results, which will be published elsewhere, are excellent and could have been obtained in no other way. Any paleontological specimens or parts of specimens could be used up to a diameter of perhaps 60 mm. Larger specimens would require an apparatus similar to that of Professor Sollas, or would have first to be cut into smaller segments.

The requirements of successful serial sectioning are the means to:

1. Grind smooth, plane surfaces without chipping.
2. Orient these surfaces with respect to some selected axis.
3. Keep successive sections parallel to each other.
4. Maintain a known and uniform distance between sections.
5. Preserve the unground part of the specimen undamaged until used.

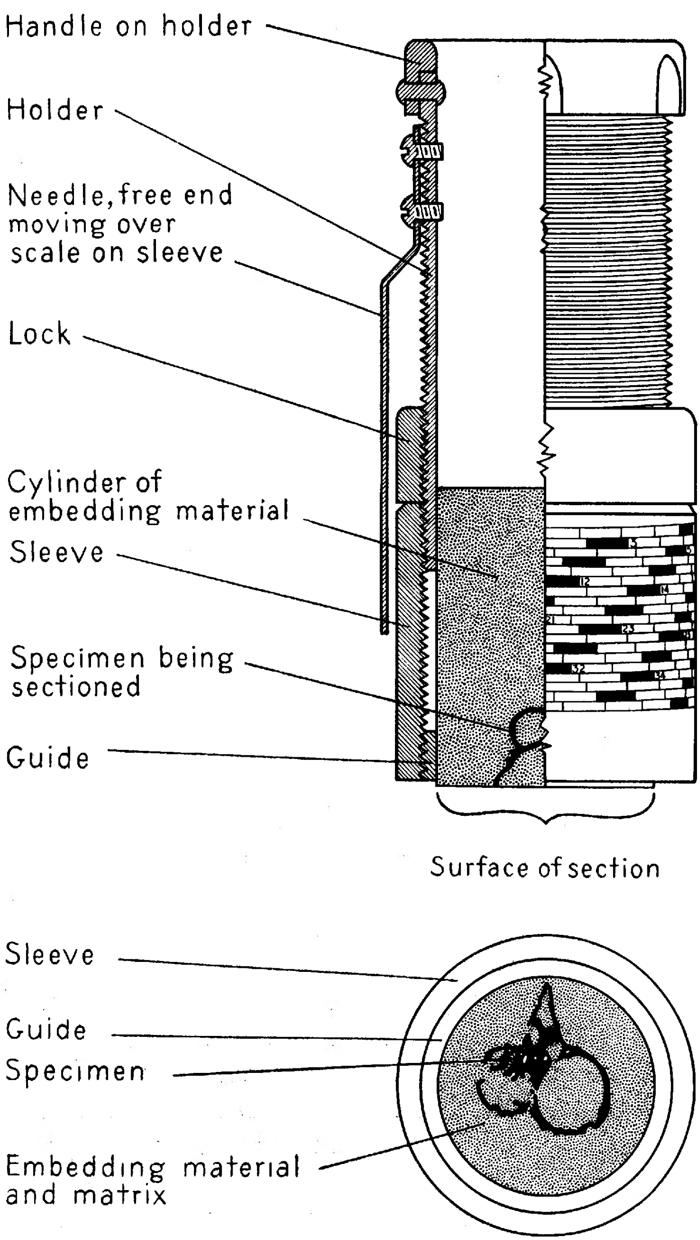

Fig. 1.—Simplified serial sectioning apparatus. The left half is shown in vertical median section and the right in external view. Below is shown the working face, with a cut section in position. In the side view, the specimen is shown protruding slightly beyond the end of sleeve and guide, ready to cut the next section.

The simplest possible procedure, holding the specimen by hand and grinding against a lap or stone, obviously cannot meet any of these conditions to the required degree and some sort of specimen holder is therefore a primary need. In the method here described, the holder, proper, is a piece of ordinary metal pipe with inside diameter several millimeters larger than the maximum dimension of the sections to be ground and the outer surface threaded for most or all of its length. In addition there is required a metal sleeve, shorter than the holder and longer than the total thickness to be covered by any one series of sections, with internal threads fitting the external threads of the holder. The sleeve should be fairly thick and of hard metal, and one end should be ground or machined to a plane surface at right angles to the axis of the cylinder.

These two pieces are all that is absolutely necessary, but several additions increase the ease of use and accuracy of results and are easily constructed. As a guide, a very short section of the same sort of threaded pipe as the holder may be permanently fixed at the machined end of the sleeve, so that its outer end is flush with and forms part of that plane surface. Some sort of grip or handle at one end of the holder will make it easier to screw this into the sleeve. A shorter, separate sleeve segment screwed onto the holder between its grip and the main sleeve forms a convenient means of locking sleeve and holder together at any desired point. Finally a pointer fixed to the holder and passing over a properly calibrated scale on the sleeve will make it easy to measure the distances between sections. The scale may be calculated from the known pitch of the threads and the outside circumference of the sleeve and then drawn on paper and shellacked to the sleeve.

For grinding, a lap may be used by simply bringing the holder to bear against its plane surface by hand. If a lap is not available—and this may be found as quick and easy in any case—two or three ordinary, flat, rectangular sharpening stones of different degrees of fineness will serve just as well. It will be found easiest to hold the specimen in its carrier stationary and upright and to move the stone across it. Both stones and section should be kept wet and washed as needed. The stones may be kept plane, if necessary, by rubbing them against each other occasionally. As the amount removed at each cut is small, hand grinding is easy and rapid, averaging five minutes or less for each section.

In using the apparatus, the specimen to be ground is embedded, with the desired orientation, in one end of a cylindrical block of suitable material. In practice, plaster mixed so as to set with fine grain and few

bubbles, dried, and then impregnated with thin shellac has been found excellent for embedding. The cylinder should be cast in the specimen holder, well greased to facilitate removal.[1] The specimen is embedded in one end of the cylindrical plaster block, and the other end should project far enough for firm attachment in the holder, as detailed below.

After removal from the mold and any further preparation (such as thorough shellacking), that end of the block not containing the specimen is inserted into the holder far enough to be held firmly, but leaving the part with the specimen freely projecting. It is fixed in this position. The holder and the embedding cylinder now projecting from it are then screwed into the sleeve far enough to bring the specimen to the far end of the latter, the end machined to a plane surface. The exact amount to be removed at the first cutting is then exposed by screwing the holder farther into the sleeve. After the first grinding, the holder is again screwed in for a determined distance and the operation repeated. Each section is ground flush with the machined end of the sleeve and guide.

The planes so ground are exactly parallel because each is determined by the machined end of the sleeve, which is exactly transverse to the axis along which the specimen is moved between cuts. The end of the sleeve and guide is so much harder than the embedded specimen that it is easy to stop grinding when it is reached. It wears slowly, but in a given case of a series of over fifty sections the total wear was less than 0.1 mm., or less than .002 mm. per section, which is completely negligible. The interval between sections is easily measured or predetermined by the amount to which the holder is screwed into the sleeve, and by making this the same each time, the sections are kept exactly equidistant from each other.

Care should be taken to keep the threads well oiled and to prevent the embedding cylinder from adhering to the guide, if one is used.

Primary records taken are a drawing or a photograph of each section. Whether drawings or photographs are preferable will depend on the nature of the specimen and on personal judgment. If photographs are used, each should be developed, printed, and retouched before the next section is ground. The specimen is left in the apparatus for drawing or photographing, and the apparatus itself is a convenient holder and means

[1]Embedding in this way is the procedure advocated in:
Kozlowski, R. 1932. 'Sur un procédé simple et précis d'effectuer coupes sérielles des fossiles.' Pal. Zeits., XIV, pp. 316-318.

Kozlowski then recommends holding the embedding cylinder by hand during the grinding. As he points out, however, this gives no assurance of equal thickness between successive cuts. It may also be noted that it does not, in fact, keep the cuts parallel and that these two disadvantages make the method too inaccurate for most purposes. His method may be useful when little accuracy is required, but in general the present procedure is hardly more difficult and certainly gives much better results.

of orientation for this purpose. For additional orientation, two small holes bored in the embedding medium (but not through the specimen) may be helpful.

If desired, wax models or copies on sheets of glass (both suggested and described by Sollas) may be prepared from the drawings or photographs for further study.